**1.**    (i)    λ distance between (neighbouring) identical points/points with same phase (on the wave)

> ***accept*** *peak/crest to peak/crest, etc.*

                                                                   **B1**

         f number of waves passing a point /cycles/vibrations (at a point) per unit time/second

> ***accept*** *number of waves produced by the wave source per unit time/second*

                                                                   **B1**

         v distance <u>travelled by the wave</u> (energy) per unit time/second

> ***not*** $v = f\lambda$ *and not 'in one second'*

                                                                 **B1**

      (ii)    in 1 second f waves are produced each of one wavelength λ

> ***accept*** *time for one λ to pass is 1/f so* $v = \lambda/(1/f) = f\lambda$

                                                                 **M1**

         distance travelled by first wave in one second is f λ = v

> ***give*** *max 1 mark for plausible derivations purely in terms of algebra (no words)*

                                                                   **A1**

                                                                            **[5]**

**2.**    (i)    it consists of nodes and antinodes / it does not transfer energy (WTTE)    B1
                   formed by two identical waves travelling in opposite directions (WTTE)    B1
                   (microwaves leaving transmitter) interfere (with reflected waves) (WTTE)    B1
                   {allow superimpose/interact/cancel out/reinforce for interfere}

      (ii)    1.wavelength of the microwaves = 2 × 1.4 = 2.8 cm                       B1

                   2. speed of microwaves in air = 3 × 108 m/s OR c                    M1
                   frequency       = 3 × 108 /2.8 × 10 – 2 (allow ecf) = 1.07 × 1010 Hz      A1

      (iii)    Place a metal grid {allow "Polaroid"} (between T and D) and rotate
                   (or place at 900) OR rotate grid/transmitter/detector                    B1
                   this causes minm/zero signal (WTTE)                              B1

                                                                            **[8]**

**3.**   (a)   (i)   amplitude correctly labelled (by **A** or in words )                       B1
                           (reject "A" as a point i.e. with no arrows)

              (ii)   wavelength correctly labelled (by $\lambda$ or in words)               B1

      (b)   (i)   same shape                                                   B1
                         moved slightly to the right consistently drawn for both waves   B1
                         (do not allow shift of more than ¼ wavelength)

              (ii)   movement is VERTICAL                                 M1
                         Q moves UP ↑ <u>AND</u> S moves DOWN ↓ shown         A1

      (c)   phase difference = 180° (degrees) OR $\pi$                       B1
              {allow "in antiphase" do not allow "out of phase"}

      (d)   (i)   recall of T = 1/f                                         C1

                             T = 1/25 = 0.04 s                          A1

              (ii)   recall of v= f$\lambda$                                   C1
                         valid substitution: e.g. v = 25 × .036                C1
                                 v = 0.90 ms$^{-1}$                   A1

                       (there are 2 possible errors – incorrect wavelength and wrong units, so
                       v = 90 m/s scores 2 marks
                       v = 0.45 m/s scores 2 marks but allow 3 marks for ecf from cand's $\lambda$
                       in (a) (ii)
                       v = 45 m/s scores 1 mark but allow 2 marks for ecf from cand's $\lambda$ in
                       (a) (ii)

      (e)   (i)   any valid suggestion: e.g. change <u>depth of water</u>              B1

              (ii)   wavelength will reduce                                C1
                       halved
                       {OR new wavelength = 1.8cm OR half cand's value shown in (d) ii}   A1

                                                                            **[15]**

**4.**     e.g. all are transverse waves (1)
so all can be polarised (under suitable conditions) (1)
all can travel in a vacuum (1)
at the same speed (1)

MAXIMUM 2 for first part          2

Discussion of other wave phenomena and how they change as wavelength changes
e.g.    diffraction
          refraction
or such things as
          the sensitivity of the eye to certain wavelengths
          photographic film for certain wavelengths
          heating effect, particularly of infra-red
          radio and its effect on electrons
          quantum effects – minimal for radio, predominant for gamma

4 marks can be given as 2,2 or 2,1,1          4

i.e. 2 topics dealt with fully or (1) topic dealt with fully and 2 topics outlined

**[6]**

**5.**     (i)     infra red is part of the e-m spectrum

**B1**

lower f **or** longer $\lambda$ than the visible region/light **or** suitable
value or range of $\lambda$

> ***accept*** *any single $\lambda$ in range $10^{-5}$ m to $7.5 \times 10^{-7}$ m or any reasonable wider range*

**B1**

(ii)   **1**    $\lambda = c/f = 3.0 \times 10^{8}/ 6.7 \times 10^{13}$

**C1**

$4.5 \times 10^{-6}$ (m)

> ***accept*** *$4.48 \times 10^{-6}$ or more s.f.*

**A1**

**2**    $T = 1/f = 1/6.7 \times 10^{13}$

**C1**

$T = 1.5 \times 10^{-14}$ (s)

> ***accept*** *$1.49 \times 10^{-14}$*

**A1**

(iii)   at least one cycle of a sine or cosine curve as judged by eye
        *ecf (ii)2*

                                                                                        **B1**

        amplitude $8.0 \times 10^{-12}$ m

                                                                                        **B1**

        period $= 1.5 \times 10^{-14}$ s

                                                                                        **B1**
                                                                                                        **[9]**


**6.**   (i)    period $= 1/500 = 0.002$s (or 2ms)                                      B1


        (ii)   at least 2 full (sine) waves of constant period (+/– 2mm)               B1
               of amplitude 3 cm (+/– 2mm in both directions)                          B1
               correct 'period' of 4 cm (+/– 2mm throughout )                          B1


        (iii)  correct substitution into v = fλ : e.g. 330 = 500λ                      C1
               λ = 0.66 m {do not allow 0.6 but allow 0.7}                             A1
                                                                                                        **[6]**


**7.**   (i)    wave sources with constant phase difference                             B1

        {NB allow "in phase" and ignore reference to frequency/wavelength/amplitude}


        (ii)   $S_1$ and $S_2$ 'share the same light' (AW)                             B1

               reference to diffraction at the <u>single</u> slit
               OR to wavefronts e.g. "same wavefront reaches $S_1$ and $S_2$ (AW)      B1


        (iii)  Constructive interference occurs at O                                   B1
               path difference is zero OR waves meet in phase (AW)                     B1


        (iv)   recall of formula λ=ax/D in any valid form (e.g. x = λD/a)              C1

        {NB allow undefined symbols provided they match the above as stated in the
        spec., otherwise they must be defined}

               correct sub. with <u>consistent units</u>: $λ = 2 \times 10^{-3} \times 0.6 \times 10^{-3} /1.8$   C1
                              $λ = 6.7 \times 10^{-7}$ m                                A1

        {NB allow ecf if mm used: i.e 2 marks for $6.7 \times 10^{-1}$ OR $6.7 \times 10^{-4}$}

 

    (v)    'fringe separation' (AW) would DECREASE                        B1

{NB allow "more fringes would be seen"}

        because $x \propto \lambda$ (AW)                               B1

{NB allow 'colour change' arguments for full marks:

        Colour would change                            B1;
        to a colour closer to the blue end of visible spectrum (AW) B1}

                                                                 **[10]**

 

**8.**    (i)    arrows show vertical oscillations                            B1
            maximum amplitude at top {allow ecf for horiz.}         B1
            less in middle AND very small (or zero) at base         B1
            {allow 1 mark only for unlabelled diagram showing representation of
            amplitude}
            {2 marks for unlabelled diagram plus an arrow}
            {allow single headed arrows}

    (ii)    wavelength = 4 × 0.36 = 1.44m                        B1

    (iii)   recall of $v = f\lambda$                                    B1
            $f = v/\lambda = 330/1.44$ (allow ecf) = 229 (or 230) Hz      B1

    (iv)   if open at both ends each end must be an antinode OR diagram    B1
            hence wavelength = 0.72m {allow ecf}                 C1
            and frequency = 458 (or 460) Hz {allow ecf}         A1
                                                         **[9]**

 

**9.**    when two waves meet/overlap/interfere/collide/superpose (AW)     B1
    the resultant displacement is the sum of the displacements        B1
    {do not allow amplitude}
    {NB allow 2 marks for good diagrams}
                                                                     **[2]**